THE ZOOLOGIST

No. 845.—November 15th, 1911.

"SLIPPER LIMPET" OR "BOAT SHELL" (*CREPIDULA FORNICATA*): ITS INTRODUCTION AND INFLUENCE ON KENT AND ESSEX OYSTER-BEDS.

By James Murie, M.D., LL.D., F.L.S.
(Member of Kent and Essex Sea Fisheries Committee).

(Plates VI. & VII.)

Preliminary Remarks.

As may be inferred from the title, the purport of this communication has reference to an American mollusc introduced into British waters, and whose presence is suspected to have a deleterious effect on the Oysters. This, be it observed, is the current opinion of many of the oystermen, though another section of them express doubts concerning its hurtful nature. The subject thus assumes an importance in so far as Oyster Fisheries are concerned, and these, it will be admitted, are historically and up to the present day a distinguishing feature of Kentish and Essex marine industries.

Before proceeding to deal with the American intruders, it may be useful to take a limited survey of what more pronouncedly are regarded as the enemies of our Native Oysters.

Among our oystermen and those engaged in the industry the so-called "vermin," looked upon by them with decided aversion, are the Five-fingers, the Mussels, and the Tingle or Dog-Whelk.

(*a*). First and decidedly foremost of these is the Starfish (*Asterias rubens*), which notoriously is well known to be a deter-

mined foe of the Oyster. This species has a wide distribution round our Kent and Essex shores, and even the deep water beyond. It likewise reaches up the river estuaries and creeks almost to the brackish water. Usually they are scattered hither and thither of various sizes, but occasionally swarm in multitudes, and literally cover some of the Oyster-grounds.

It is not our intention to enter into the manner in which the Starfish masters the Oyster and extracts the flesh. The latest and most reliable authority on the subject, Dr. P. Schiemenz,* shows from his observations and experiments that this is effected by sheer force. Large Oysters, therefore, are comparatively safe, the "brood" and "half-ware" permitting of easier extraction. The saving clause for the fishermen as respects the Starfish is that dredging for them has hitherto been a paying concern. At otherwise intervals of slack times—the spring and fall—the fishermen from various stations in Kent and Essex dredge for them, and the catch is sold as manure to the farmers. Moreover, it is asserted that the Starfish occasionally render a benefit by thinning the numbers of the Mussels so detrimental to the Oyster-beds (?).

(*b*). The Mussels (*Mytilus edulis*) come under a different category, namely, being only indirectly injurious to the welfare of the Oyster communities. They in no way attack the Oyster bodily, but they as effectually destroy "brood," "half-ware," and the "ware" by their byssus or gelatinous threads (like spiders' webs), entangling seaweeds, hydroid zoophytes, stray cockles, broken fragments of shells, &c., and, above all, their collecting of muddy and sandy material; the heaping of these latter stuffs around and over the Oyster simply means their effectual destruction. Mussels notwithstanding are profitable under certain conditions, but require cultivation as do Oysters.

(*c*). As to the "Whelk-Tingle" or "Dog-Whelk" (*Purpura lapillus*), their manner of attack on Oysters differs materially from either of the preceding. They fix themselves by their fleshy foot to the shell of the Oyster, and penetrate this by a lingual rasp-like borer; thence partake of the soft material of the Oyster's body to its final detriment. There is, though, no

* Mittheil. des Deutsch. Seefishver, Bd. xii. 1896; and Journ. Mar. Biol. Assoc., n. s., vol. iv. p. 266.

market for the Whelk-Tingle, which in Oyster-culling is either thrown anywhere overboard, or at sparse times is crushed under foot on deck, but seldom or ever collected and taken ashore to be destroyed for the ultimate benefit of the Oyster-bed.

Its ally, the Common Whelk (*Buccinum undatum*), some aver, has an occasional turn at the Oyster, but the injury they commit is slight compared with the Tingle. Besides, there is a regular fishery—"Whelk Trotting"—existent in the Thames estuary and Harwich neighbourhood. The catch therefrom as a constant trade is either sent to market and sold as food, or despatched to the North Sea trawlers as bait. Other enemies we leave aside as apart from the object at present in view.

"Slipper Limpet" or "Boat Shell" (*Crepidula fornicata*).

This Gastropod, as already intimated, is an American form of but quite recent acquisition among the British marine fauna. Its distribution in the North American continent is the Atlantic Coast from the Maritime Canadian Provinces along the United States shores to Florida and north of the Gulf of Mexico.

Although in the colloquial the animal is named "Limpet," yet it differs structurally in the soft parts, and the shell does not possess the conical form of our Common Rock Limpet (*Patella vulgata*). Thus it comes under another genus—*Crepidula*. Instead of a Limpet's figure, the shell is ovoid or oblong in shape, with a curled or twisted beak.

In our British specimens it may range from one-eighth of an inch to nigh 2½ in. in long diameter, and in breadth from ⅛ in. to 1¼ in. in greatest width. The height varies $\frac{1}{10}$ in. to 1¼ in., according to the different age and stage of the animal when alive. Much or nearly all depends, however, whether the shell is flattish or more arched on the top curve, and this varies to a remarkable degree, according to the contour of the object to which it is adherent.

A remarkable feature of the shell, and that which has given rise in the United States to the names of "Slipper Shell" and "Boat Shell," is the presence of a horizontal thin plate of porcelain-like nacreous material. This separates the powerful muscular foot from the softer viscera, which lie ensconced safely and securely above. Compare in Plate VI., figs. 7 and 8, where

the "step" or shelf in question is shown from below in the empty shell. In fig. 12 the upper surface has been partly removed, and the mantle-covered dorsum of the animal exposed. In fig. 11, on the contrary, the sole of the fleshy sucker-foot disk, &c., are demonstrated. Again, fig. 13 illustrates a mid-longitudinal section of the shell and position of the shelf, while fig. 14 gives a view of the same with the viscera, &c., *in situ*. Fig. 15 is a transverse median section with the soft parts in place, the thin shelf seen separating the foot from the upper soft parts.

Taking into consideration that the sea-margins of the United States are, so to say, the headquarters of several species of *Crepidula*, and particularly that of *C. fornicata*, it behoves us to hear what the American Naturalists, Fishery Commissioners, and others report concerning the structure, habits, and influences of the said mollusc to its surroundings. Leaving aside the works of pure conchologists of both earlier and more recent dates (T. Say and A. A. Gould, or W. H. Dall, for example), we may first quote Theodore Lyman's* simple description of the *C. fornicata*. He remarks that they are:—"In great numbers on odd shells, generally those occupied by *Eupagurus* [Hermit Crab], the smaller ones often sticking to the larger. The expanded animal has two snail-like horns with eye-specks at their bases, and between them a pair of lobes (tentacles?). The front part of the body and head have the form of a rather thin plate of tissue, which is very movable, while the sucking disk rests on the 'step' in the shell, and is very thick and muscular; the front edge of the disk is prolonged in the shape of a movable flap. Round the edge of the shell runs the mantle, which may be considerably contracted. The gills lie in a sheet on the inside of the roof of the shell. The *Crepidulæ* were laying eggs which adhered in clusters to the surface on which the animals lay. Those clusters contained a bunch of transparent sacs, each of which was full of embryos. These embryos, before leaving the sac, have an active motion. They take on the form of little bags, tied as it were near the top; the bag itself is filled with yolk-cells, while the loose flaps above the

* "Habits of Animals observed at West Yarmouth, Mass.," in Proc. Boston Soc. Nat. Hist. vol. vii. p. 78 (1859–61).

constriction are bordered by rows of vibratile ciliæ, which create brisk currents, and serve to move the embryo. When the *Crepidula* is at rest the front edge of the shell is a little raised, and the tentacles thrust a little forth. They move slowly from time to time."

In our waters, as yet, we have not met with the "Slipper Limpet" on shells occupied by the Hermit Crab, but certainly we shall keep a sharp look-out for them. The remainder of Lyman's description of the soft parts corresponds or tallies with our examination and dissection of quite a number of the British-bred specimens. See drawings of same in Plate VI., figs. 11, 12, 13, 14, and 15.

In his Report to the Commissioner of Fish and Fisheries,* Prof. A. E. Verrill, in describing the fauna of the gravelly and shelly bottoms of the bays and sounds off Massachusetts, remarks of *Crepidula fornicata* that it:—"Was one of the most abundant species, often occurring adhering to each other in great clusters, the lowest ones in the group adhering in turn to dead bivalve shells, pebbles, shells of living *Fulgur* and *Sycotypus*, and still more frequently to these shells when dead and occupied by the larger Hermit-Crabs (*Eupagurus pollicarus*). The dead shells of this *Crepidula* were often found in great accumulations, covering considerable areas of bottom, and with little admixture, either with other shells or with sand and gravel."

The same writer (*l. c.* p. 475), in enumerating the animals inhabiting the Oyster-beds in brackish water, says:—"Among the most common shells that are found attached to Oysters are *Crepidula fornicata* and *C. unguiformis*. They both occur together on the upper as well as the under valves, and in all cases retain their ordinary characters."

See the figures in accompanying Plate VII. of how *C. fornicata* grasps and perches on Oysters, Mussels, &c., in the estuarine and creek waters of Kent and Essex, all showing its habits and attachments have not altered in new surroundings.

During the Great International Fisheries Exhibition, held

* "Report upon the Invertebrate Animals of Vineyard Sound and the adjacent Waters, with an Account of the Physical Characters of the Region," in Rep. U. S. Commiss. Fish and Fisheries, vol. i. p. 417 (1873).

in London in 1883, when acting on one of the committees, we had the pleasure of constant intercourse with the United States representatives, among whom were Browne Goode and several others of his scientific colleagues. Among the United States exhibits of Economic Mollusca were specimens of the "Slipper Shell" (*Crepidula plana*) and the "Boat Shell" (*C. fornicata*). These, however, did not then particularly attract attention. In the Catalogue of Exhibits, though Lieut. Winslow, in allusion to them, states that they "are neither directly injurious nor beneficial, they are often associated with destructive Gasteropods. In addition, their absence from an Oyster-bed is one of the many indications of its deterioration." He further remarks that "when present in large numbers they form one of the indications of the health of an Oyster-bed."

The above epoch-making Exhibition certainly gave a stimulus to the consignment of American Oysters for replanting, for only a few years previously had they been introduced to the market.

The last to mention and doubtless the most important contributions to the literature of the "Slipper Limpets" are those of Prof. E. G. Conklin (1897–98). The first memoir* deals mainly with their embryology, and is illustrated, besides woodcuts, by nine large plates. His second paper† treats rather of their Sexual Dimorphism, accompanied by three plates of remarkable varieties of the shells of different species.

As it is not our intention to enter into minutiæ of the biological aspects of the molluscs in question other than what applies to their influence on our fisheries, we shall only extract (from Conklin) such points as have a bearing thereon.

Referring to the New England species, *C. fornicata*, *C. plana*, and *C. convexa*, he mentions they all show remarkable individual differences in the shape of their shells. This, he avers, is dependent on the shape and position of the mantle edge, which moulds the shell to correspond with the surface upon which the animal is attached. Hence it may be unusually broad and flat,

* "The Embryology of Crepidula: a Contribution to the Cell Lineage and Early Development of some Marine Gasteropods," Journ. of Morphology, April, 1897, pp. 1–226, with nine plates and thirteen diagrams.

† "Environmental and Sexual Dimorphism in Crepidula," Proc. Acad. Nat. Sci. Philadelphia, 1898, pp. 435–444, with three plates.

or highly arched, or concave, or twisted or short or long, as the case may be.

C. fornicata occurs on the shell-back or on the ventral surface of the American King-Crab (*Limulus polyphemus*).

In early stages the "Limpets" (*C. fornicata*) move about, but when nearly half-grown they lead an irrevocably sedentary life. They occur on muddy sea-bottoms in curious chains* of often ten or twelve individuals, perched on the back of each other—heads all in one direction. Such chains are often found in which there is not a single male, and yet I have never found an unfertilized female.

The sexes are separate; the smaller-sized males, as a rule, lead a more roving life up to a certain age.

Breeding season, early summer to mid-August. The eggs, contained within a bunch of capsules (therefore analogous to those of our British Whelk), are seen about midsummer. After August absent, and instead clusters of spat are found within the shell. Conklin believes that copulation occurs only once in a lifetime. He found a seminal receptacle consisting of a convoluted tube within the female, and which at times was filled with spermatozoa. The latter, therefore, mingles with the ova before the egg-capsules are formed within the oviduct of the female.

The eggs of the several American species of *Crepidula* vary remarkably in size. Those of *C. fornicata* (now a British inhabitant) are nearly the smallest, although this animal is the largest of the several species. In one bunch 55 capsules were counted, and the eggs in each numbered 240, or a total of 13,200 to a single female.

The "Slipper Limpets" are supposed not to be increasing in numbers in American waters (?).

Regarding Conklin's elaborate researches into segmentation of the ovum of *Crepidula* species and the dwarf race of *C. plana*, these are aside from the purport of the present paper.

Their British Introduction and Results.

It may be inferred from what precedes that up till within a comparatively recent date conchologists had never met with nor

* The "windrows" of some American writers.

recorded *Crepidula* as among the indigenous genera of British shells. Having located America as the original habitat of these "Slipper Limpets," the question arises, How and when were they brought alive to Britain?

A case in point may be cited, namely, that of our Common Periwinkle (*Littorina littorea*). This stranger to the United States fauna is supposed to have got there in 1868* from having been shot out alive among the ballast of the shipping. Since then it has become naturalized and spread abundantly. But the close adherence of the living "Slipper Limpets" to Oysters bespeaks that *they* undoubtedly were the means of conveyance. Proof of this will be given further on. Here sufficient for our purpose to refer the reader to paragraphs on the introduction of American and Dutch Oysters *for laying* in the 'Fish Trade Gazette' of Oct. 10th, 1891 (p. 11), where it is stated this was some fifteen or twenty years previously, otherwise between 1870–1876.

Among data concerning the presence of the "Slipper Limpet" on the coast of England facing the North Sea we give the following:—

York and Lincoln.—Arthur Smith,† of Great Grimsby, has recorded his having found the shells of *Crepidula fornicata* near Cleethorpes in November, 1887, and he mentions that he learned they were brought thither with consignments of [barrelled] American Oysters. Furthermore, B. Sturges Dodd‡ makes the rather important statement that in February, 1887, two barrels of Oysters were received from a firm from New Basford [query: New Bedford, U.S.—J. M.], in which were several dozen of *Crepidula*, *Anomia*, and *Barbatia*. He reasons therefrom that, seeing the Oysters imported to Britain are relaid at Cleethorpes and elsewhere in the Humber-mouth neighbourhood, they (*Crepidula fornicata*) ultimately may hereafter become acclimatized. H. Wallis Kew§ also alludes to their presence on the Lincolnshire coast. Quite lately, on inquiry of Herbert Donnison, Inspector of Eastern Sea Fisheries District, he tells us they

* Winslow, Cat. Econom. Mollusca of U.S.A.

† 'Yorkshire Naturalist,' 1888, p. 27.

‡ Proc. Malacological Soc. vol. i. pt. ii. p. 31 (March, 1894).

§ 'Yorkshire Naturalist,' 1889, p. 358.

have not been observed by him in the Boston (River Witham) estuary. We have no information as to the southern portion of the Wash, or around Norfolk and Suffolk coastal lines generally.

Essex and Kent.—It has to be noted that about 1880 or a few years earlier Mr. Musson, a Liverpool firm, established an agency (Mr. Stammers) at Brightlingsea. The former regularly imported American Oysters, and these were transmitted on to Brightlingsea in quantity, and sold and distributed among the various Essex Oyster merchants and Oyster growers for relaying. The business, so far as we know, still continues. At a meeting of the Essex Natural History Field Club, held at Brightlingsea in September, 1891, Mr. Walter Crouch* exhibited the shell of a specimen of the "Slipper Limpet" (*Crepidula fornicata*) fixed to the back of an Oyster-shell. This he had picked up on the beach, and he traced the origin of the specimen as derivative of the American Oysters imported. Furthermore, in March, and again in April, 1893, he received from John Bacon,† a Burnham dredger, live examples of said species. This form of shell-fish, Bacon assured him, he had seen in the Rivers Crouch and Roach for some fifteen or more years previously, but then they were quite scarce. He seemed doubtful as to American Oysters or spat being laid down in those rivers (?). He mentioned they were common in the Blackwater. In May and in September, 1898, Mr. Crouch‡ received from Dr. Laver (of Colchester) living specimens from the River Colne, these containing masses of yellow spawn inside the shell. The specimens were large ones.

Coming to the Thames estuary, the Oyster-beds in "The Ray," opposite Leigh (now practically closed), formerly passed in succession through the hands of Messrs. Baxter, Tabor, Hammond, and, lastly, Hobart. We are indebted to Frank Bridge, formerly foreman, who tells us that it is quite over twenty years since Americans, *viz.* "East Rivers" and "Blue

* 'Essex Naturalist,' vol. v. p. 260.

† *Ibid.*, vol. viii. p. 36.

‡ *Ibid.*, vol. x. p. 351 (1898). Here may be added the names of a few other observers, to wit: W. M. Webb (1897), Wm. Cole (1904), J. E. Cooper and John French (1906). Their examples were respectively from Brightlingsea and the Crouch River (see 'Essex Naturalist,' vols. x., xiii. and xv.; and Proc. Malacol. Soc. vol. vii.).

Points," were laid on the beds. From their inception living groups of the so-called "Slipper Limpets" (*Crepidula fornicata*) were seen adhering to the Oysters. At first not much notice was taken of them, though Bridge, thinking they might be saleable, cleaned some and took them to London, but he could find no market, and there the matter dropped. Gradually, however, they increased in numbers on the grounds, and now are scattered broadcast in "The Ray" (adjoining Canvey Island), and along the shore to right opposite Westcliff. Few comparatively are found on the sandy flats, but they are innumerable on the sides of the rivulets and near the muddy ground towards low-water mark, where they seem to thrive amazingly. Further down the estuary, namely, at the shore-mouth of the Swale, many years back, American Oysters were there relaid. As time passed the *Crepidulæ* therefrom flourished and spread about, finally invading the Sea Salter and historic "Royal Whitstable Natives" beds. This, notwithstanding the great care and labour bestowed on the culture of these beds by constant dredging, weeding, and selection of the "ware," &c. Incidentally, it may be added that A. S. Kennard* has intimated his finding *Crepidula fornicata* near Herne Bay, where also E. F. Wheeler (Fishery Officer) tells us they are to be got. The whitebaiters in Queenborough neighbourhood (mouth of the Medway) also occasionally get the shells in their drag-nets.

To sum up, it goes without saying that the "Slipper Limpet" or "Boat Shell" has now established itself firmly, and become naturalized† and acclimatized in nearly all the Oyster-grounds of Essex and Kent. With our present knowledge it would seem as if it were beyond the power of man to root them out.

It now comes to the essential, practical issue of the facts; otherwise expressed: Are the "Limpets" to be classed among the vermin of the oystermen, or is their influence to the good, bad, or indifferent?

Public attention has been drawn to the topic by the occur-

* Proc. Malacol. Soc. vol. ii. p. 134 (1896).

† Alfred Russel Wallace lays some stress on the distinction between Naturalization and Acclimatization (see his article in 'Encyclopædia Britannica' (9th ed.), vol. i. p. 84).

rence of a legal case* last July, wherein "Limpets" stood forth prominently. At the trial were numerous practical oystermen as witnesses. What struck one was the apparent contradictory, though explainable, evidence given respectively by the Burnham and West Mersea dredgers. The question resolved itself into whether at end and settlement of a five-years' lease the ground was left in an untenantable condition through the negligence shown in clearing off the superabundance of "Limpets." For the plaintiff it was affirmed the "Limpets" *were pernicious*, their quantities so enormous,† and their attachment to the Oysters such as to impede the latter's growth, besides detraction from their food. For the defendant it was asserted that "Limpets" *were not injurious* to Oysters. The latter fed well, even where surrounded by them, both rising or opening simultaneously when feeding. They did not eat the Oyster-spat. The more the "Limpets" the cleaner the ground from mud.

Notwithstanding individual diversity of opinions, it ultimately came out that in the main both parties were unanimous as follows: that the root and sore of the evil lay in the great expense incurred by the Oyster-growers—in extra hands, time, and labour bestowed—in dredging for the "Limpets," and the chopping them off singly (by "cultack") from their very firm adherence to the Oysters. On the other hand, this constant or over-dredging induced another evil, namely, it caused the young Oysters to become "stumpy" or "dumpy" or "nubby" (local terms for imperfect or broken rimmed), which considerably lowered their mercantile value. In the words of one notable Oyster-grower, "Limpets"—"if not 'vermin,' are a horrible nuisance." The Oyster industry of Essex and Kent is therefore on the horns of a dilemma, with no bright prospects in the horizon. It behoves, then, those financially interested, with the

* That of W. R. Campion (plaintiff) *versus* H. L. Brand Cooke (defendant) relative to "The Ray" Oyster-laying on the Crouch River above Burnham. Judge Tindal Atkinson gave a verdict in favour of Campion, owner of the grounds.

† In one minute's dredging on the Crouch River ground at issue four hundred and ninety clumps of "Limpets" were counted. Another witness stated that in the Blackwater grounds thirty-five tons of "Limpets" were dredged within four weeks.

aid of Fisheries District Committee, to institute inquiries and research in furtherance of such steps as might lead to the mitigation of the mischief threatening a prominent and important commercial industry of the two counties.

There are other matters concerning "Limpets" (*Crepidula fornicata*), e. g. their habits, relations to associate organisms, wherefore deleterious to British stock—though presumed to be less troublesome in America—uses to be put to, &c., which we reserve for a future occasion. Meantime, the present accompanying illustrations may help to convey an idea of how things stand with the Oyster's parasite messmate.

Appendix. — Since the foregoing was in type, and on my exhibiting specimens of the "Slipper Limpet" at the Linnean Society Meeting (Nov. 2nd), Prof. Dendy called my attention to a paper bearing on the subject by a pupil of his: "On the Occurrence of Protandric Hermaphroditism in the Mollusc *Crepidula fornicata*," by J. H. Orton, Proc. Roy. Soc. B. vol. 81, (1909). Unfortunately this had escaped my attention, else should have been referred to in the body of the present paper, especially as based on animals collected on Essex shores.

At the same time, Orton's researches and deductions, like Conklin's (*l. c.*), dwell more particularly on the biological or physiological phases. Indeed, with some few exceptions, they only indirectly pertain to the everyday wants and working of the local fisheries, therefore irrelevant to the object of our paper. Withal, we here give in extract Orton's otherwise interesting investigations, which seem to be a continuation of Conklin's on the sexuality of the genus. He first draws attention to and gives a diagram of seven *Crepidulæ*, in arched form on an Oyster-shell (similar to our fig. 6 in Plate VII.). The three lower "Limpets" are females, above which an imperfect male, and then three fully developed males. He agrees with Conklin as to chains once formed are thereafter permanent fixtures, whereas the youngsters are motile. Five diagrams follow, illustrative of sexual anatomy; one of these shown as hermaphrodite by possessing both penis and uterus. He

further enters into the sex relations of the chains by tabular data and otherwise. As above indicated, the females are at bottom, the hermaphrodites in middle, and males atop, their size decreasing upwards.

From his examination of the gonad, it looks doubtful whether pure males with only sperm in them are ever found in *C. fornicata* (?). The youngest forms are doubtless males as regards function, and the oldest exclusively females. He infers: "*There is no doubt that all the individuals of this species are born males, and change in the course of their life-history into females.*" He suggests that chain formation and hermaphroditism are in some way casually connected. They would seem to have arisen along with, and favoured the acquisition of, Protandric Hermaphroditism. Thus *Crepidula fornicata* appears to have become adapted to a sedentary life without losing any of the procreative advantages of a free-living habit.

After some remarks on dwarf females, Orton concludes with memoranda on sex phenomena in allied species, and in those of the Limpet genus, *Calyptræa*.

To Prof. Conklin, all the same, is due the credit of first promulgating the idea of conversion of the sexes in *Crepidula*, which Orton has afterwards worked out in a creditable manner. The theoretical or speculative views of both authors, notwithstanding, leave still a gap in application to Fisheries' practical interests other than explanatory of the prolific nature of the parasitical "Limpet."

We can corroborate Orton's allusion to West Mersea chains being larger and more numerous than outer coast ones, and his anatomical diagrams fairly representative. (Compare our figs. 11, 12, 13, 14, and 15 in Plate VI.) He makes a few introductory remarks on its American origin and distribution, with Dodd's hint of 1880 introduction and favourable propagation in Essex.

We may here emend the paragraph (*ante*, p. 405) by mentioning that since it was in type we have had the good fortune of receiving from a shrimper specimens of Hermit Crab-shells with numerous small "Slipper Limpets" attached to them. Nay, more, a young Shore Crab (*Carcinus mænas*) with several on its back. These were got in the trawl-net, Sea Reach,

between the Chapman Light and Holehaven. This is but another link in the evidence of *Crepidula fornicata* retaining its native choice of objects to settle on in its new British home.

DESCRIPTION OF PLATES.

Plate VI.

Fig. 1.—On the left (*a*) is a bunch of the capsules and a few extruded eggs, as seen by us among specimens in early and mid-July. On the right (*b*) are some of the more elongated spat ("veligers"), carried within the shell in Thames live specimens gathered in October.

Fig. 2.—Dorsal view of three of the shells grading from smaller to larger size.

Fig. 3.—Interior of shell of a bigger animal, showing the shelf or horizontal nacreous plate.

Figs. 4 and 5.—Exterior top view of larger shells. On fig. 4 at the apex a little younger "Slipper Limpet" has become attached.

Fig. 6.—A group of three of the "Limpets," as affixed to each other, varying in size.

Figs. 7 and 8.—Interior of the shells of older and larger animals; *s*, the nacreous shelf, comes half-way down the shell. The colouring of the latter varies considerably.

Figs. 9 and 10.—Exterior lateral surface of two full-grown shells of *C. fornicata*; *be*, spiral or slightly twisted beak.

Fig. 11.—View of lower surface, with the animal itself in place; *f*, sucker-foot (*mesopodium* or sole of Conklin), slightly contracted. Its thinner flexible extension downwards in figure (so-called *propodium*) has beyond it the horns and mouth-lobes.

Fig. 12.—A top view, in which a portion of the shell has been removed, exposing the mantle covering the visceral structures of the animal; *m*, the mantle; *g*, the gills. On opposite side, viscera, contorted blood-vessels, turn of gut, &c.

All the figures from 2 to 12 inclusive are drawn to natural size.

Fig. 13.—A vertical, median, longitudinal section of a dried shell, wherein *s* represents the horizontal shelf, and *be*, outside of beak.

This and the succeeding figures in this plate are two-thirds their natural size.

Fig. 14.—A similar section, with the fleshy parts of the animal *in situ*; *s*, the shelf; *v*, the viscera above it; and *f*, muscular foot below.

FIG. 15.—A transverse middle section of the animal in the shell; *v*, viscera above the shelf, and *f*, the fleshy foot below.

FIG. 16.—A small smooth-surfaced pebble on which a young "Limpet" has fastened itself.

FIG. 17.—The upper valve of a Mussel (*m*), whereon four "Limpets" (*l*) of different sizes are piled one on the other.

FIG. 18.—An Oyster (*o*) covered with barnacles, whereon (*l*, *l*) six "Limpets" varying in age are attached.

FIG. 19.—An Oyster (*o*), to which a "Limpet" (*l*) is affixed. On the surface between them a group of barnacles, serpula, &c.

FIG. 20.—Two Oysters (*o*, *o*) (marginal view), on which are several "Limpets" (*l*, *l*) of different sizes.

PLATE VII.

FIG. 1.—A "Limpet" (*l*), on which a young Oyster (*o*) has fixed itself; the contrary of the other specimens.

FIG. 2.—An Oyster (*o*), upon which a "Limpet" (*l*) is attached.

FIG. 3.—Two Oysters (*o*, *o*), held together by a "Limpet" (*l*). Barnacle colonies on all three.

FIG. 4.—A young Oyster (*o*) almost covered by a "Limpet" (*l*).

FIG. 5.—An Oyster (*o*), to which a pile or chain ("windrow" of some American naturalists) of "Limpets" (*l*, *l*, *l*) is affixed. Several small-sized "Limpets" are seen adhering to the Oyster, and also to the larger "Limpets."

FIG. 6.—Another view of the same specimen, whereon it can be seen there are ten "Limpets" (*l*, *l*, *l*, *l*, *l*) fastened one above another in an arched form; their beaks all in one direction facing the observer; (*o*) Oyster.

FIG. 7.—An end view of a Mussel (*m*) surrounded by "Limpets" (*l*, *l*, *l*, *l*, *l*). A few small "Limpets" and some barnacles are adherent to the larger "Limpets." From the lips of the Mussel there issue fibres of its byssus, and these are attached to a dead Cockle-valve (*co*) and fragments of other broken pieces of shells.

FIG. 8.—An agglomeration of six Oysters and several "Limpets" (*l*, *l*) of various sizes.

All the figures in Plate VII. are drawn to two-thirds natural scale.

MISCELLANEOUS NOTES ON ZOOLOGICAL INSTITUTIONS RECENTLY VISITED IN EUROPE.

By Capt. Stanley S. Flower, F.L.S.

(Concluded from p. 345.)

13. Stuttgart, Wurtemberg.

(i) *Zoological Gardens.*

If anyone, wishing to start a zoological garden in the British Isles, were to ask me which *one* of the standing menageries, public and private, would best repay them to study before embarking on their enterprise, I should say, as far as my present (May, 1911) experience goes, that, of the forty-eight menageries I have actually inspected, the Tiergarten, at Doggenburg, near Stuttgart, would be the most profitable to visit. The site is small, the collection is small, and the animals are of no great value, but the arrangement is such that everything is exhibited to its best advantage. The lover of animals who visits Doggenburg will carry away with him the impression that he has seen but few species, but these all carefully provided for and happy; the schoolchild will have seen the principal types of the vertebrate fauna of Europe, and enough exotic ones to excite his further interest; the casual visitor will not know exactly what he has or has not seen, but will feel satisfied that he has had "his money's worth."

About five years ago Herr Nill's famous, though small, zoological garden in Stuttgart had to be closed, as the site was required by the State. A new railway station is now being built on it. Meanwhile Herr Theodor Widmann contemplated starting a really large zoological garden in the capital of Wurtemberg, and, to begin with, having purchased Herr Nill's cages, opened, about 1907, a small garden at Doggenburg, a suburb on the heights above Stuttgart. Herr Widmann then proceeded to travel about the world in order to visit other zoological gardens and collect notes on their management. When I was staying in Stuttgart in May, 1910, Herr Widmann had not

yet returned, and I was informed that Herr Nill was the actual proprietor of the Doggenburger Tiergarten.

The live animals that I saw there were Grivet Monkeys, three species of Macaques, Drill, Marmoset, a magnificent European Lynx, Serval, Genets, Striped Hyæna, Wolf, Fox, Pine-Marten, Beech-Marten, Badger, Otter, Coati, two Bears, Hedgehogs, Squirrels, Marmot, Dormouse, Hamster, Rats, Mice, Ponies, "Stein" Donkeys, Chamois, Goats, Sheep, a pair of Red Deer, a pair of Roe Deer, a remarkably fine Arabian Camel, three Wild Boar, a Spotted Dasyure, a very nice collection of European birds and some foreign species, Parrots, Pheasants, &c., Tortoises, Snakes, Toads, Newts, Axolotls, and a select and attractive series of small fishes.

Besides the Restaurant (a prominent feature in most zoological gardens), the most noticeable buildings were the "Flying Cage," in which White Storks were nesting, and a combined Bird House and Aquarium, cleverly arranged and charmingly fitted up. The outer walls were mostly occupied by aviaries, communicating with out-of-door flight cages. Down the centre of the house there was a double row of small compartments, with a service passage between them, all lit from above, on the aquarium principle. Each of these little compartments had evidently been the subject of much careful thought on their designer's part: the scheme of decoration differed in almost each case, and combined providing comfortable homes for the little animals on exhibition with giving the visitors both pleasure and amusement. While the Batrachians lived in miniature gardens well supplied with water, the Japanese Mice played about in a completely furnished sort of doll's house upholstered in blue and white, and a family of Rats occupied an original house, the domed roof of which was made of an Armadillo's skin.

(ii) *Museum.*

The Royal Natural History Museum (Königliches Naturalien-Kabinett zu Stuttgart) is situated in the State Archives Building, in the Neckarstrasse, conveniently near the centre of the city.

This museum is of very special interest, not only from the extent and value of the collections which it contains, but also from its being one of the oldest zoological institutions in the

world. Its origin was the collection of curiosities owned for centuries past by the ruling family of Wurtemberg (the oldest specimen now in the collection is said to have been there for three hundred and ten years*), and the institution was placed on its present and more scientific basis in 1826.

The ground-floor is occupied by the famous Wurtemberg geological collection. Special attention may be called to the skulls of *Labyrinthodon*, *Mastodonsaurus*, and *Metopias*; to the series of skulls of various species of *Belodon*; to the skeleton of *Dacosaurus maximus*; and to the group of twenty-four Fossil Lizards (*Ætosaurus ferratus*).

The first floor contains the general zoological collection. The more recent additions (at the date of my visit in May, 1910) to the series of stuffed mammals are extremely well set up, the accomplished taxidermist being Herr Fred. Kerz, Inspector of this museum. The specimens I particularly noted on the first floor were:—

Mammals.—A good collection of stuffed Monkeys (including *Theropithecus gelada* and *T. obscurus*) and Lemurs.

A fine *Felis puma patagonica*.

A stuffed Sea-Otter (*Latax lutris*), obtained in 1889.

Many South African Antelopes received from von Ludwig in 1837.

A male Hartebeest (*Bubalis tora*), received in 1879, which is stated to have lived for two years in the Hamburg Zoological Gardens.

A male Mrs. Gray's Waterbuck (*Cobus maria*) obtained from von Heuglin in 1855.

Three interesting Gazelles (*Gazella "lævipes"*) from Keren, Bogos, obtained from von Heuglin in 1862. The Gazelles from North-east Africa are still so little known that it is very difficult to name them specifically.

A female *Gazella arabica* from the Royal Menagerie, 1816.

A male African Buffalo (*Bos caffer*, subsp.), labelled "*Buffelus pumilus*," from the South Cameroons.

A beautiful female Giraffe, labelled "*Giraffa capensis schillingsi*," from German East Africa.

* See Prof. E. Fraas, Führer Kgl. Nat. Kab. Stuttgart, i. p. 1 (2nd edition), 1906.

A nearly white specimen of a male *Cariacus virginianus* from Maine, U.S.A., obtained in 1863.

The big collection of Deer's antlers: Red Deer (*Cervus elaphus*), &c. on this (the first) floor, and Roe (*Capreolus caprea*) on the second floor.

Birds.—The fine collections of stuffed Birds of Prey and Bustards.

The adult female stuffed Shoebill (*Balæniceps rex*), obtained from von Heuglin in 1855.

The stuffed Great Auk (*Alca impennis*).

Reptiles.—A male Terrapin (*Staurotypus triporcatus*) from Guatemala. Terrapins of this family—the *Dermatemydidæ*—are rare in collections, and this individual is a particularly striking specimen.

A large stuffed Garial* (*Gharialis gangeticus*, or *Garialis gangetica*) obtained from Dr. von Barth in 1854; this specimen now measures approximately in total length fourteen feet, but nearly half of the tail is missing.

The second floor contains the collection of the fauna of Wurtemberg, and the general osteological and palæontological collections. Among the stuffed animals the following may be specially mentioned:—The last Lynx, a male, killed in Wurtemberg, in 1846; the last Wolf, also a male, killed in Wurtemberg, in 1847; two Beavers, both males, from near Ulm, on the Danubian side of Wurtemberg, one obtained in 1828 and one in 1869, the latter being the last Wurtemberg Beaver; a male Red-breasted Goose (*Bernicla ruficollis*) obtained at Leonberg in January, 1844. Among the fossils from abroad I noticed some Egyptian ones from the Fayûm, including the skull of a *Zeuglodon isis*, E. Fraas, 1906.

14. Vienna, Austria.

(i) *Zoological Gardens.*

The Imperial and Royal Menagerie of the Palace of Schönbrunn, Vienna, is not only the oldest existing Zoological Garden

* Although W. Theobald, in 1876, corrected the spelling of the name of the Long-snouted Indian Crocodile, the words "Gavial" and "*Gavialis*" still occur in books. To those who, like myself, know the animal alive in India, the "v" instead of "r" sounds very unsuitable. See Lydekker, "Royal Nat. Hist.," 1896, vol. v., page 30.

in the world, but one of the very best. This institution has reached its present high state of efficiency under the direction of Inspector Alois Kraus, Ritter des Kais. Österr. Franz Joseph Ordens.

Herr Kraus was formerly in the Austrian navy, and gained both professional and zoological knowledge on board the frigate 'Novara,' in her celebrated voyage round the world in the years 1857 to 1859. In 1866 he took part in the battle of Lissa, being then in command of a section of marine artillery. In more recent years Herr Kraus was selected to accompany the late Crown Prince Rudolf in several ornithological and sporting tours, including visits to Egypt. The scrupulous cleanliness of the Schönbrunn menagerie, and the alertness of the keepers employed there, give evidence of the good naval training of the man in charge, while the healthy appearance of the live stock and the accuracy of the labelling show that both practical and systematic zoology are subjects with which he is familiar.

This menagerie was founded in 1752 by Francis I., Emperor of Germany, and the great Empress Maria Theresa, the original Superintendent being Adrian van Steckhoven, a native of Holland.*

I formed a very favourable impression of this menagerie when I was in Vienna in 1905, and this was more than confirmed in 1910, when I had the privilege of staying at Schönbrunn for a week and thoroughly seeing the working of this institution at all times of the day.

The animal houses, with one exception, all date from the time of Maria Theresa. They have been, in most cases, altered from time to time in matters of fittings and methods of lighting and ventilation, and some of them have been enlarged; but substantially they are the same buildings as they were more than one hundred and fifty years ago, and it is wonderful to consider how well they answer their purpose. The house for small birds, however, is not now considered to be sufficiently ventilated, and it is proposed to utilize it for keeping reptiles in, and the winter quarters of the Flamingoes will be enlarged so as to form a permanent home for the small bird collection.

* Loisel, 'La Ménagerie impériale de Schoenbrunn,' Nouvelles Archives des Missions scientifiques, t. xv., Imprimerie Nationale, Paris, 1907.

The exception, mentioned above, is the new Monkey House, built since 1905, which appears to me to be neither useful nor ornamental.

A new piece of ground on the side of the hill at the back of the menagerie was opened to the public in 1910; in it fifteen very nice new paddocks for Chamois, Mufflon, &c., have been constructed. Each paddock is on the slope of a hill, and ledges of real stone (not cement) project from the ground. An eighteenth century ice-house which was found to occupy part of the line of these paddocks has been preserved in position.

The wild birds in the Schönbrunn gardens are numerous and very tame. It was particularly charming to see the Green Woodpecker (*Gecinus viridis*) feeding on a lawn within a few yards of the visitors.

During the week we were at Schönbrunn, neither my wife nor I saw a single Squirrel, Rat, or Rabbit at large in the grounds. We asked if there were any, and were told there were none—because the Emperor did not permit loose rodents in his gardens.

Contents of Schönbrunn Menagerie at end of April, 1910.

I noted representatives of one hundred and forty-eight species of Mammals, three hundred of Birds, twenty-five of Reptiles, and seven of Batrachians; in all, four hundred and eighty species, not counting domestic races. The number of individual animals, on the authority of Herr Kraus, was 2300.

Mammals.—*Primates.*—I saw about forty-nine Monkeys of eighteen species, the most interesting being a Douroucoli (*Nyctipithecus*) and twenty-four Lemurs of eight kinds.

Carnivora.—At least fifty-three Æluroidea of twenty-one species, including a very large red European Lynx, and a male African Chita (*Cynælurus jubatus*), presented by Prince Henry Liechtenstein, which has lived here, I am told, for over twelve years, a very long time for a Chita in captivity (or possibly in a wild state also).

The Cynoidea numbered ten specimens of five species. A Dalmatian Jackal was of special interest from its locality. The howling of the European Wolves in the early morning was most musical, but I felt glad, each time I heard the sound, that the musicians were safely caged.

Thirty-three, or a few more, animals of fourteen species represented the Arctoidea, including a nice series of Bears, one of which, identified as *Ursus behringi*, Herr Kraus told me was thirty-four years old. A Kinkajou (*Potos flavus*) has now been eight years in this menagerie, and the keeper told me that another specimen lived here for ten years.

The only representative of the Pinnipedia was one Seal. This animal stands up in the water in its pond, with a kindly, almost angelic, expression, and then, with its fore flippers, suddenly splashes water over the visitors who are looking at it, to the amusement of everyone who is not "in the line of fire."

Insectivora and *Chiroptera* are not represented.

Rodentia.—Sixteen species. Eight Capybaras make a fine exhibit.

Proboscidea.—Four Asiatic Elephants—a bull, two cows, and a female calf born here in July, 1906. The Elephants' indoor cages are paved with wood, this wood pavement being periodically renewed. A fact worth recording is that the Schönbrunn bull Elephant in 1909, when in a state of sexual excitement, climbed over the top of a stout iron fence 1·80 metres (5 ft. 10¾ in.) high.*

Perissodactyla.—Two Sumatran Rhinoceroses (both females), two American Tapirs, three Chapman's Zebras, an African Wild Ass, and some Ponies.

Artiodactyla. — Among the Pecora the following may be specially noted:—Magnificent specimens of the European and American Bison, one of the former was born at Schönbrunn, May 5th, 1910; a pair of very pretty, medium-sized domestic Zebus from Mysore; two Anoas; three Addax Antelopes from Tripoli, one of which had been ten years here—the Cow Addax at Schönbrunn had horns of an unusual pattern, they lacked the spiral twist characteristic of the species, and curved simply backwards like the horns of the Sabre-horned Antelope (*Oryx leucoryx*); a series of seven different breeds of European and

* In designing cages for animals, it is very useful to have some data as to what height of fence is, or is not, capable of keeping them within bounds under circumstances of unusual excitement. A giraffe, when frightened by dogs, has been known to jump over a fence 1·75 metres (5 ft. 9 in.) high in the Calcutta Zoological Gardens; *vide* Sanyal, 'Management of Animals in Captivity,' Calcutta, 1892, p. 153.

Asiatic domestic Sheep; a pair of Sudan Giraffes; and two Reindeer.

The Tylopoda were represented by all six existing species, and the Suina by a young male East African Hippopotamus, and Gallician Wild Swine.

Edentata. — An Armadillo (*Dasypus villosus*) shared a cage with some Macaques in the Monkey House.

Marsupialia.—Besides Kangaroos and Australian Opossums (*Trichosurus vulpecula*), which breed here as they do in London and other European zoological gardens, I saw a very nice Pouched-Squirrel, referred to *Petaurus*, from Southern New Guinea.

Monotremata—Two Echidnas, which had both lived for six years here.

Birds.—*Passeres.*—I counted one hundred and thirty-five different species; those that pleased me most were four Bearded Tits, two Nuthatches, five Nutcrackers, a white Jackdaw, five Indian White-Eyes (*Zosterops palpebrosus*), a Scimitar Babbler (*Pomatorhinus montanus*), which had been six or seven months here, and a Swallow (*Hirundo urbica*) was of interest, as, although it lived in a small cage, it was in good feather and tame; the keeper told me that this bird had been hand-reared from the nest and was now two years old, and that another hand-reared nestling had lived in a cage for nine years here.

Picariæ. — Eight Green-billed Toucans (*Rhamphastos dicolorus*) living together in one cage made a very fine exhibit, as did also five Blue-cheeked Barbets (*Megalæma asiatica*) in another cage.

Accipitres.—A magnificent Crested Serpent-Eagle (*Spilornis cheela*) should be noted.

Herodiones.—The large wading-birds' aviary is of a very good design. At the end of April we noticed that the Night-Herons and Spoonbills were busy nesting in trees, and a White Stork was sitting on a nest built on the ground.

Odontoglossæ.—Thirty-nine Flamingoes (*Phœnicopterus roseus*) in one enclosure made a very beautiful sight. Herr Kraus told me that he feeds his Flamingoes on grain, chopped horse meat (seven kilos. of meat is the daily ration for thirty-nine birds), and a mixture of food as supplied to the "soft-bills."

Two individual Flamingoes have lived between twenty-two and twenty-three years here.

Limicolæ. — Five species, including the Ruff (*Machetes pugnax*), of which a large number of male birds formed a good exhibit.

Reptiles.—*Chelonia.*—A Pond-Tortoise (*Emys orbicularis*) was remarkable on account of its exceptionally large size; Prof. Franz Werner told me that it had probably come from Lake Balaton, in Hungary. These large *Emys* apparently also occur in Southern Volhynia, as in 1909 Mr. Lydekker kindly showed me a specimen living at his house in Hertfordshire, which he had obtained during his trip to Count Joseph Potocki's estate at Pilawin in 1907.

Crocodilia.—One specimen of each of the three following species—*Crocodilus porosus*, *C. palustris*, and *Alligator sinensis*. All rarities in European menageries.

Ophidia.—The collection of Snakes consisted of five species of small non-poisonous Colubrines, one *Boa constrictor*, one Tree-Boa (*Epicrates striatus*), one *Python spilotes*, a very dark-coloured specimen of *P. molurus*, which Prof. Werner told me was probably from Java or Sumatra, and four individuals of *P. reticulatus*—a small one which had been bred at Herr Fockelmann's place at Hamburg, two medium-sized ones, and one giant which has lived about twelve years here, and is now supposed to be over 7 metres (say, 23 ft.) in length.

Batrachians. — *Ecaudata.*—A very large specimen of the South American Horned Frog (*Ceratophrys cornuta*), which the keeper told me is fed on the common European Frogs. A very fine pair of the South American Frog (*Leptodactylus pentadactylus*). Both male and female were very large and in beautiful condition. They have to be kept in separate cages. Fourteen individuals of the American Giant Toad (*Bufo marinus*), all in beautiful condition, and some very richly marked and coloured.

Caudata.—Prof. Werner told me that the Japanese Giant Salamander has now lived for about twenty years here.

Two things which no visitor to Schönbrunn should miss seeing are:—

(i) The beautifully clean and neat and richly stocked Palm House, built in 1882 from the designs of Herr F. Segenschmid.

(ii) The Maria Theresa Pavilion in the centre of the Menagerie. In it are twelve mural medallions of great zoological interest, the subjects being animals that were living in this Menagerie in the middle of the eighteenth century. I learn from Prof. Loisel that these were painted about 1759 by Gregor Gugliemi. Prof. Loisel has published ('Nouvelles Archives des Missions scientifiques,' t. xv. page 241) a list of the species represented in the medallions. On comparing his list with one that I had made independently, I find that we are not in all cases quite in accord either in numbers or identifications as far as the mammals are concerned.

(ii) *Museum.*

It is impossible to give here a description of the magnificent building of the Natural History Museum of Vienna, or of the rich collections that it contains. Attention will only be called to the recent additions to the series of stuffed mammals extremely well mounted by Herr Fred. Kerz, of Stuttgart, especially a Gibbon, a Baboon, a Siberian Tiger, a Puma, and a Bear (*Ursus pruinosus*), and to sixteen out of the many thousands of interesting specimens that are exhibited here.

1. Model of skeleton, mounted, of *Megaladaphis edwardsi*, one of the largest of the subfossil Lemurs of Madagascar.

2. Seal (*Phoca vitulina*), born in the Schönbrunn Menagerie, 1908.

3. Hyrax (*Procavia slatini*, Sassi), the type, from the Sudan.

4. *Rhinoceros simus cottoni* from the Lado Enclave, 1909.

5. *Equus quagga lorenzi.*

6. A fine male *Capra ægagrus cretensis.*

7, 8. Two Shoebills (*Balæniceps rex*).

9. Incomplete skeleton of a Dodo.

10. Stuffed Great Auk.

11. Very large *Testudo daudinii*, presented by the Hon. Walter Rothschild.

12. Very large male *T. marginata.*

13. Large *T. pardalis* from Harar.

14, 15. Pair of Garials; male about 5·50 metres (18 ft. ½ in.), female about 5·00 metres (16 ft. 5 in.) in total length.

16. Large *Tomistoma schlegelii.*

(iii) *Institution of Experimental Biology.*

The fine building in the Prater in Vienna formerly called the "Vivarium" is now occupied by an institution for zoological and botanical research attached to the university, and financially supported by the State. A full and most interesting account of this institution and its work has been recently published by Dr. Hans Przibram,* and a shorter notice by Prof. Gustave Loisel.†

I would like to take this opportunity of expressing my thanks to Prof. Wilhelm Figdor and his colleagues for their kindness in allowing me access to all parts of the building, and for answering my many questions about its contents, while I was in Vienna in the spring of 1910. It is very encouraging to see that there is a place where the scientific staff are really able to devote their time to watching the live animals under their care, instead of (as in most zoological institutions) being only able to do so in intervals snatched from administrative business.

While referring the reader to Przibram's and Loisel's papers for a general account of this institute, eight points may be specially noted here:—

(i) *Adelsberg Cave Fauna.*—Specimens of *Proteus anguinus*, Crickets, Beetles, Crayfish, and Isopod Crustaceans from the caves of Adelsberg are living under natural conditions of temperature, darkness, &c., in a crypt under the building. Dr. Megusar, carrying an electric lamp, very kindly conducted me through this crypt and pointed out its interesting inhabitants.

(ii) *Batrachians.*—I saw ten species of Batrachians alive here: including two Menobranchs (*Necturus maculatus*) received in 1905, so nearly five years in captivity; one American Hell-Bender (*Cryptobranchus alleghaniensis*); the *Proteus* mentioned above, which breed here; one *Siren lacertina*; and a female Toad (*Bufo vulgaris*), from Greece, which measured, from snout to vent, about 155 mm. (6⅛ in.), thus rivalling Fatio's Sicilian giantess (see Boulenger, 'Tailless Batrachians of Europe,' 1898, p. 217).

(iii) *Fishes.*—A small Electric Cat-Fish (*Malopterurus elec-*

* Przibram, "Die Biologische Versuchsanstalt in Wien," 'Zeitschrift für biologische Technik und Methodik.' Karl J. Trübner, Strassburg, 1910.

† Loisel, "L'Institut de biologie expérimentale de Vienne," 'Nouvelles Archives des Missions scientifiques,' t. xv. Imprimerie Nationale, Paris, 1907.

tricus), received October 14th, 1904, *i. e.* five years six and a half months here and still alive.

(iv) *Aeration of Tanks.*—I was surprised to find that the system employed here for aerating both the fresh- and sea-water tanks was that of pumping in air under pressure, machinery being installed for the purpose.

(v) *Insects.*—The "Faras el Nabi" (Mare of the Prophet, *i. e.* Mahomed) (*Sphodromantis bioculata*), a large green Praying Mantis, not uncommon in Egypt, has been bred to three generations here. Individuals live for less than one year here. In the Giza Zoological Gardens our attempts to breed this showy insect in captivity have been unsuccessful owing to their combativeness, but I found that in Vienna they tie up the arms of the female before the male is placed in the same cage with her, so that she is unable to hurt him.* Dr. Przibram has given an illustrated account of how this tying is done in the 'Archiv für Entwicklungsmechanik der Organismen' (Leipzig, Nov. 1909).

(vi) *Vivariums.*—The practical type of cage, useful for keeping various kinds of small animals in, employed here and called the "Kammerer-Terrarium" (after Dr. Paul Kammerer), is worthy of notice.

(vii) *Insect Cages.*—The "Przibram-Organtinkäfig" (called after Dr. Hans Przibram) employed here is a very light and simply constructed cage, admirable for its purpose.

(viii) *Mealworm Breeding.*—Very large numbers of Mealworms are of course required in an institution of this kind for feeding the live stock, and the problem of how to keep a sufficient supply of these larvæ on hand without going to the, at times most expensive, expedient of buying them, has been solved by employing the "Mehlwurm-Futterzucht," invented by Dr. Franz Megusar, a system which, with the inventor's kind permission, we are about to try at Giza.

* "Ferocity of Female Mantis." See A. H. Mosse, 'Journal Bombay Nat. Hist. Soc.' xx. No. 3 (1911), p. 879, and L. C. Coleman, *loc. cit.*, No. 4 (1911), p. 1167.

NOTES AND QUERIES.

MAMMALIA.

Serotine Bat in Essex.—A short time ago I received from my friend Mr. R. M. Presland, of Manor House, Oak Hill, Woodford Green, Essex, three Bats for identification: one proved to be a Noctule (*Nyctalus noctula*), one a Pipistrelle (*Pipistrellus pipistrellus*), and the third a Serotine (*Vespertilio serotinus*). On looking up *serotinus* in 'A History of British Mammals' (Barrett-Hamilton), pp. 130–139, I find that this Bat has only been previously recorded three times from Essex, and that the example under notice (a male), obtained at the Manor House, Woodford Green, on July 14th, 1911, forms the fourth record for the county, and probably the nearest record to the Metropolis. The other three Essex examples recorded are—one killed before 1863 at Coggeshall, and detected by Miller Christy in 1883; a second taken by Miller Christy at Broomfield in 1894; and a third taken at Pitsea, near Tilbury, in August, 1906 (Barrett-Hamilton, 'A History of British Mammals,' p. 132). I am indebted to my friend Mr. J. L. Bonhote for the identification of the above Bat.—F. W. Smalley (Challan Hall, Silverdale, Lancashire).

Lesser Rorqual Whale at Lowestoft.—Observing a note in a local paper that a Whale had been washed ashore at Lowestoft on October 14th last, I journeyed over on the 16th, and found the rather dilapidated strong-smelling carcase rolling about in the wash of a heavy sea, within a few yards of the sea-wall, abreast of the herring-basin. Most of the skin had been abraded when I saw it, and the head with the jaw-bones had been removed and carted away by a local knacker, who presumably had an idea of extracting oil from the beast, two heaps of pieces of flesh of the size of a pumpkin then being piled under the sea-wall ready for removal. The pectoral fins were also gone. I was fortunate in discovering one large slice of flesh (looking very like the pickled beef in the days of our ancient mariners) from the throat of the animal, still showing the characteristic wrinkles of the Rorquals, and I hunted up a photographer who had snapped the carcase before the ghouls had been at work upon it. The photograph plainly showed the elongated jaw-bones (bare of flesh), the white

barred pectoral fin, and the corrugated under part of the Lesser Rorqual (*Balænoptera rostrata*), thus placing its identity beyond doubt. It had in all probability been run into by a steamer. I estimated its length at about twenty-five feet.—ARTHUR H. PATTERSON (Ibis House, Great Yarmouth).

AVES.

Nocturnal Habits of Turdus iliacus.—On reading Mr. Stubbs's very interesting notes on the movements of Redwings during dark nights (*ante*, p. 361), I then understood why I always failed to secure any of these birds when roosting in the hedges, their unusual alertness and wildness offering such a contrast to the habits of the Song-Thrushes and other small birds at night. When living at Moy View, Redwings, Thrushes, and various small birds roosted regularly during the winter in two hawthorn hedges at the sides of the middle avenue. Wishing to obtain some Redwings alive, I made several attempts from time to time to take them on the roost, using a lantern on dark nights to show where they sat on the branches, but all my efforts were in vain, for no sooner did the light shine on the bushes, and before we got near, the birds rose with loud cries from the roost and vanished into the darkness. I then tried the plan of keeping the light shaded, and only showing it when at the hedge-side, but nothing would induce them to remain; almost invariably on the darkest nights, even without a light, we could not get near the hedge before the birds left with their wild cries. This habit at night was different to that of the Song-Thrushes and other small birds, sitting quietly on their perches, as if dazzled by the light, and in most cases allowing themselves to be taken by the hand. — ROBERT WARREN (Ardnaree, Monkstown, Co. Cork).

The Nocturnal Habit of the Redwing.—In 'The Zoologist' (*ante*, p. 361), Mr. F. J. Stubbs contributes an interesting article on the nocturnal habits of the Redwing. I gather from his theory that he considers the calls of the Redwings overhead during the colder half of the year to be chiefly due to the wanderings of the birds during the hours of darkness rather than to these being closely connected with the migratory movements of this species. Perhaps to a certain extent his surmise may be correct, but I cannot think for a moment that they are entirely non-migratory actions. He is good enough to favourably quote notes of mine from 'The Naturalist' three years ago, but asks why I should consider the phenomenon now to be (1)

as extraordinary, and (2) as migratory? Well, as to No. 1, the night of Nov. 4th, 1907, was certainly extraordinary as the greatest Redwing-night inland (by their calls in the air) that I ever remember, not only by my own experience, but chiefly by the observations of several of my friends, and over a wide area of this part of the West Riding (*vide* 'The Naturalist,' 1908, pp. 17, 18).* The calls during that night were both incessant and continuous, and were certainly abnormal, or otherwise extraordinary. In the same note, however, I partly appear to support Mr. Stubbs's theory by saying ('The Naturalist,' 1908, p. 17): "But the numbers to be seen in the daytime were trifling compared with those that passed over almost nightly." As to No. 2 (migratory), I think that I was justified in calling it thus from the fact that in this district we chiefly hear the Redwing at night during its migratory periods. For my own part, I am almost invariably first notified of its arrival in October by its call overhead in the darkness. We may hear desultory calls during the second and third weeks in October, and again in late February and in March, but here it is chiefly during the last week in October and the first week in November that their cries may be heard almost nightly, and sometimes for several hours together on suitable evenings. Therefore, I think that I am correct in associating their persistent cries at that season of the year with the immigratory movements which we know to be in progress then. They are most frequently heard on still dark nights, especially if the weather should be misty or damp.

Finally, I may say that I do not consider the periodical call of the Redwing in the evening to be at all equivalent to the cries of larger birds over a well-lighted town on a foggy or very misty night. I well remember the cries of various waders, ducks, &c., during a dark foggy night at King's Lynn when I was residing there twenty years ago, and how I stayed in the streets all the night until daylight endeavouring to trace *the migration*, as I thought it was at the time. But immediately the street-lamps were turned out (fully half an hour before any sign of dawn) the calls of the birds ceased, and the birds themselves disappeared. Thus when daylight came I did not see a single bird, although for many hours together I had been listening to a perfect babel of bird-voices overhead. My supposed migration was merely my first experience of a great crowd of birds

* In Yorkshire, thanks to the good services of the Yorkshire Naturalists' Union, members are able to meet together from different parts of the county, and to compare notes.

dazzled by the lights of a town, and which could not, or would not, pierce the surrounding gloom. This, however, I cannot attribute to the autumnal calls of the Redwings, which are certainly to a very great extent connected with their migratory movements. Mr. Stubbs suggests that probably Redwings may indulge in these nocturnal wanderings and callings at their nesting haunts. A friend, who has observed Redwings and Fieldfares nesting in Scandinavia, tells me that, although he repeatedly heard Fieldfares flying and calling at night, yet he had never observed the same trait in the Redwing.—H. B. Booth (Ben Rhydding).

Habits of the Redwing.—Mr. Stubbs's communication respecting this bird in 'The Zoologist' (*ante*, p. 361) must have arrested the attention of every reader, and all, I think, will agree that the remarks of the writer of the paper are worthy of discussion. To me his experiences appear unusual, if not unique—so much so that it would be satisfactory to know that records have been kept of this almost continuous movement of the bird in question after dark, and also—a matter of still greater interest—with reference to the occasions on which he has heard its song in England. After fifty years' observation of our birds and their habits—and during thirty years eyes and ears were in constant training and use—I should agree that the "seep" of the bird is *occasionally* to be heard on winter nights when there is a change in the weather, but certainly not on *any* night, and again tolerably frequently in the early spring when the birds are preparing for departure, although then not with any certainty or regularity. It is in October and early November, at the yearly immigration of the species, that the travelling call may be heard nightly, and, moreover, every few minutes when the wind is favourable for their passage. The Redwing is a restless bird, and apparently much more influenced by the weather than the rest of the Thrush tribe; it certainly becomes thinner, and succumbs to cold more readily than the others. This may account for its frequent change of locality during the winter months, and, being of a loquacious disposition, thus calls our attention to its travels. Then as to song. Congregations are not uncommon in the early spring when the birds are collecting previous to departure, and then it is that we hear them in "murmuration" or "jubilation." It is at this time, too, that an occasional attempt at song—much in the style of the broken and imperfect December song of the Thrush—may be heard; but anything at all resembling the beautiful song described by those who have visited the bird in its home has only twice delighted me, *viz.* at Little

Ealing in 1863, and at Kingsbury in 1877, on both occasions in the early spring.—F. D. Power (Brixton).

Late Swallows.—On Nov. 2nd I observed two Swallows (*Hirundo rustica*) circling round my house and garden, and on the 4th the number increased to five. I thought the recent gale would probably have driven them away, but the following morning they were still here. Before the first date I had not noticed any for some weeks.—R. H. Ramsbotham (Elmhurst, Garstang).

Little Owl and (?) Wood-Sandpiper in Lincolnshire.—Although the gradual spread of the Little Owl (*Athene noctua*) in the eastern counties is pretty well known, it may interest some readers of 'The Zoologist' to know that it has become almost numerous in Lady Winchilsea's park at Haverholm, where, as a woodman informed us, on Aug. 24th last, he first began to notice it only about two years ago. In walking through the park on that date, accompanied by my son, we happened to see one of the Owls roosting against the bole of a large elm where a branch had once been broken off, and were so entertained with its alertness and the rapid hawk-like flight with which it made off that we followed it up to the clump of trees whither it had sought refuge, and were there so fortunate as to encounter the man. He called the birds "Little Dutch Owls"—apparently their familiar name thereabouts—and pointed out to us some old and decaying ashes, not far from our path, in which he informed us one or two pairs of the Owls had bred, in holes in the trees, this year, and where we should be almost certain to see some of them, "if we could rouse them." Walking over to these trees we soon found one of the Owls, and again followed it the better to observe its actions in daylight, and should doubtless have seen more of them had our attention not then been drawn away from the Owls by three Sandpipers, which we noticed settling by the side of a stream. There they allowed us to approach them closely, and, although the general resemblance between Green and Wood Sandpipers is such as to render the positive identity of birds thus casually seen (especially immature examples, as these undoubtedly were) always uncertain, I had so good a view of them as to have but little hesitation in pronouncing them to belong to the latter species (*Totanus glareola*).—George Bolam.

Long-tailed Duck breeding in Orkney.—I have received news of the Long-tailed Duck (*Harelda glacialis*) breeding in Orkney during the summer of 1911.—O. V. Aplin (Bloxham, Oxon).

Migration of the Coot (Fulica atra) in Bedfordshire.—Last year I visited the various breeding haunts of this species in the above county to ascertain the numbers nesting in the respective localities for comparison with their aggregate at other times of the year. The nesting haunts of the Coot in Bedfordshire are practically limited to the pools in a few of the private parks. At Luton Hoo, Woburn, Battlesdon, and Tingrith some thirty pairs may breed in all, and their numbers during the remainder of the year appear to be about in proportion, hence we may presume that, apart from forced migration owing to severe frosts, such are resident birds throughout the year. Whereas at Pouthill Lake, the largest sheet of water in that county—upwards of thirty-three acres in extent—different facts are gleaned. Here some eight to ten pair of Coot nest yearly, and these home-bred birds are very considerably added to, when autumn approaches, by immigrants that remain there until the following spring. I have a record counting over one hundred Coot there as early as July 30th in last year, half of which would be recent arrivals, and on Sept. 23rd of the present year some one hundred and fifty were on that sheet of water. From this time of the year onwards their numbers further increase, and many hundreds will be invariably seen together there during the winter months, the largest number I have a note of being on Dec. 10th, 1910, when about six hundred were counted, but, revisiting the lake on Dec. 29th following, only some three hundred and fifty remained. Coot are occasionally seen on the waterways of that county, but such occurrences are generally restricted to their movements in September and October. From inquiries and observations made by my friend Mr. Chas. Oldham at the large reservoirs at Tring, in Hertfordshire, which are the nearest extensive nesting haunts, he informs me that the number of Coot there is likewise increased during the same period of the year. Whence these migrants come, whether partly from some other breeding waters in this country or Continental immigrants, yet remains to be proved, and upon which subject further information from other contributors would be valuable.—J. Steele Elliott (Dowles Manor, Shropshire).

Gulls hawking for Insects.—Sept. 12th was a very hot and sultry day, and by the evening the stagnant air was filled with myriads of winged ants. This induced a number of Black-headed Gulls (*Larus ridibundus*) to adopt what seemed to me a most unusual method of feeding. Rising about one hundred to one hundred and fifty feet up these sea-birds joined a number of House-Martins and "hawked" for

the tiny insects. I spent at least half an hour watching the Gulls through my glasses, and there could be no mistaking their movements. Flying slowly round in the still atmosphere, every few seconds one of these birds would snap at some invisible object, frequently rising or swerving in its flight to effect the capture, just as a Swallow or Martin would do under similar conditions.—Collingwood Ingram (Westgate-on-Sea).

Eared Grebe in Worcestershire.—On Oct. 9th an Eared Grebe (*Podicipes nigricollis*) was seen by an angler in the canal at Stoke, near Droitwich, to be in difficulties amongst the water-plants at the side of the canal, and he secured it by the help of a landing-net. Next day he took it to Messrs. Spicer & Sons, Birmingham, from whom I subsequently acquired it. It was found to have been suffering from recent gunshot wounds, which doubtless accounted for its easy capture. It is a female, and, I believe, immature, and small, but, as it was already set up before I saw it, I do not know the length. Other measurements are: wing, 4·67 in.; tarsus, 1·44 in.; culmen, 0·75 in. The stomach was quite full, and contained, Grebe-like, a number of its own breast-feathers, a few tiny pebbles, two or three univalve shells, a quantity of remains of coleopterous insects, and a red ant. These contents, after maceration in cold water for a few minutes, produced a filtrate of a bright dark green colour, changing in the course of a week to a dull cloudy yellow, due, so I am informed, to the presence of biliary matter, and this, I think, must be correct, for there was no other substance present likely to produce such a colour, unless possibly the beetles might be responsible. The colouring-matter in these, however, would not, I believe, be soluble in cold water, though to what extent the digestive process might affect them I do not know, and should be glad to be informed. There is but scant information as to the visits of this species to Worcestershire. Mr. F. Coburn stated in the 'Birmingham Daily Mail,' Nov. 16th, 1907, that he had at different times seen two on the canal reservoir at Bittel; whilst the late R. F. Tomes, in the 'Victoria History,' mentions occurrences on the Avon, but as his notices in the Worcestershire and Warwickshire Histories are almost identical, it is doubtful to which county those occurrences belong, though presumably he intended his readers to understand that he had records for both counties; data, however, are wanting. One would hardly look for an Eared (or any other) Grebe on the top of a straw-stack, yet in 'The Naturalist' for 1851, p. 21, an instance is given of one that was observed in such a situation, and was knocked

down by a snowball!—THOMAS GROUND (Whittlesea, Waverley Road, Kenilworth).

One of the Causes of our Rare Birds disappearing.—While I entirely agree with Mr. Warren's action (*ante*, p. 391), and hold no brief on behalf of the trading collector, I feel that a protest should be made against the assumption that, because a Yorkshire dealer or collector holds a large stock of duplicate Ospreys' and some Golden Eagles' eggs, this is the cause why "the Golden Eagles and Ospreys of Scotland are so steadily vanishing." One is accustomed to these statements from the more hysterical bird protectionists, but it is surprising to find it coming from a naturalist of Mr. Warren's reputation. In the first place, it is a well-known fact that the Golden Eagles of Scotland, instead of vanishing, have enormously increased in numbers, in spite of a certain amount of egg-taking, *because the old birds are not shot down now on many deer forests.* On the other hand, the Osprey is on the verge of extinction, but, as Mr. Warren must be aware, this is due to the wanton slaughter of the birds on migration through Ireland, and not to egg-collecting at all. How many clutches of British Ospreys have been taken of late years? Yet eyrie after eyrie is deserted in spite of strict protection, and simply because one or both of the birds have been barbarously murdered, either on their way south after the nesting season, or moving northward in the spring, to be finally recorded in the pages of the 'Irish Naturalist.' We are not guiltless in the matter in England, but I am inclined to think that the English birds are generally of Scandinavian rather than Scotch origin. Without knowing anything of Mr. Warren's correspondent, I will undertake to say that there is not a single British-taken egg among the fifty duplicate Ospreys' eggs of which he writes. In all probability they are American eggs taken some years ago before the passing of the present protection laws. I have looked in vain for some words of reprobation from Irish naturalists of note when these murders were duly recorded. Mr. Warren has told us how the gamekeeper and the sporting tenant have just exterminated the Sea-Eagle in Ireland. Cannot Ireland be content with the destruction of her own fauna without robbing Scotland as well? —F. C. R. JOURDAIN (Clifton Vicarage, Ashburne, Derbyshire).

A Note on Continental Birds.—I spent my two months' holiday in 1911, in July at Berchtesgaden, in Bavaria, and in August at the Rhone Glacier. I was not as fortunate as usual in my observations of birds, for after the very hot month of June nearly all the song-

birds were silent, and the lovely woods in that most charming place, Berchtesgaden, "the gem of Bavaria," seemed almost deserted. At the beginning of July the Garden Warbler and Bonelli's Warbler were singing, but they gradually ceased, and the only very interesting birds I noted later on were the Golden Oriole and the Crested Tit. When I left I had only a list of thirty-eight species to my credit, the Buzzard and the Sparrow-Hawk representing the birds of prey. In order to reach my second chaplaincy we took a long and delightful journey through Salzburg, the Tirol, Innsbruck, and the Arlberg to Luzern; there we had the Black Kite hovering lazily over the Lake, and the Alpine Swifts with their shrill and pleasant cries breeding in the Old Town at the covered bridge. At the Rhone Glacier we heard the shrill cries of the Marmots even in the hotel; they abounded in the neighbouring rocks. Five of these little animals are kept in a cage in the hotel grounds, and when winter comes on, and Herr Seilers's great hotel is closed on Oct. 1st, they are transferred to the cellar to sleep until the spring; but last winter, the director told me, one of the five did *not* sleep, but, he added, "he is sleeping now!" The predominant bird in the Rhone Valley is certainly the Alpine Pipit; there were numbers of these birds always about the hotel stables, where sometimes three hundred and fifty horses rested for the night. Are there two species there? Some of the birds were quite greyish, with no spots whatever on the breast, whilst others were profusely spotted, and their backs and wings were a rich brown. We walked twice over the Grimsel Pass, and saw no birds—all was still and desolate, and twice over the Nucka Pass, and there, at a height of about 7990 ft., the House-Martins had their nests in the Nucka Blicts Hotel; no other bird of the Swallow kind was to be found. On our second excursion to the Nucka Hotel, which commands what I think is the most wonderful view in Switzerland—the majestic Weisshorn shining in perpetual snow fifty miles away—we had our best "find." My wife drew my attention to a brown bird dropping into the road from an overhanging rock; it was followed by five or six more. They were quite new to me. We drew near cautiously, and I observed them carefully with my glass. They seemed very like Thrushes, but were of a uniform dull brown with a red spot below the scapulars. They repeatedly flew up and down from the rocks to the road, uttering a musical cry something like a Sky-Lark's, and I was greatly puzzled as to their identity. Going on a little farther to the Hôtel Belvedere, at a height of about 7300 ft., as we stood near the verandah outside, a bird alighted on

the road a few yards off, which I saw at once was a Rock-Thrush in blue and yellow plumage. He was quite tame, and hopped and pecked about till a youth threw a stone at him and frightened him away. I believe, therefore, that the brown birds were young Thrushes in autumn plumage, for Mr. Backhouse, in his very useful 'Hand-book of British Birds,' thus describes them: wings dark brown, beneath *orange rufous*, with a narrow bar of brown at tip of each feather. This was my fourth experience of this beautiful and very interesting bird: (1) at the Hospice of St. Bernard, 8120 ft., singing; (2) Pilatus, 7000 ft., singing with uplifted wings and alighting on the rocks; (3) at the Grimsel, near the Todten See, at about 7000 ft.; these also descending with wings uplifted. A circumstance which occurred at Berchtesgaden is perhaps deserving of notice. At the Hôtel Bellevue the Yellowhammers were so tame they came into the dining-room regularly when we were there to be fed by the waiters. There were also flocks of small birds which flew at a considerable height, and alighted in the tops of the trees at Oberwald; these, my kind friend, Herr Seilers, assured me, were Snowfinches. I should have taken them for some species of Redpoll. They were constantly crying "gip, gip," but I found it impossible to identify them from their height in lofty trees.—CHARLES W. BENSON (Balbriggan).

Errata.—In the October number of 'The Zoologist' (*ante*, p. 391), at the end of the first paragraph, for "female" read "male."—E. P. BUTTERFIELD (Wilsden, Bradford).

MOLLUSCA.

Notes on the Breeding and the Boring Habits of Pholas crispata.—*General Remarks.*—*Pholas* is found around the Fife coast wherever suitable environmental conditions exist. The rocks on this coast are for the most part of the Lower Carboniferous age, and consist of alternating layers of sandstone and shale, with here and there a thin band of limestone. These bands have been thrown into a series of folds now denuded, and as the shale and sandstone do not resist the waves equally the sandstone forms long ridges or reefs, while the shale is cut out, as it were, leaving long trough-like hollows, which are locally called "lakes." It is in these "lakes" that *Pholas* is most commonly found. In any one they will, as a rule, be found evenly distributed, but those at the upper or landward end are smaller, because they are longest out of the water between tides.

The Body.—*Pholas* has a thick, white, elongated, fleshy body, and from the anterior end of the animal protrudes a long tube traversed by the two canals or siphons, through one of which the water neces-

sary for the respiration is drawn, and this water is ejected through the other. Through another opening in the mantle a short, thick, fleshy foot protrudes.

The Shell.—The shell is equivalve, gaping at both ends, swelling below, thin; transparent and white in appearance. It differs notably from most acephalous molluscs, for there are certain accessory pieces, smaller than the true valves, and placed near the hinges; these extra parts being connected in some way with the creature's peculiar mode of life. In addition to differences of structure, there are also differences in the use of the valves as compared with what is observed in such a form as the clam. When a clam is disturbed it contracts, completely closing the shell. In the case of *Pholas* the valves must remain open to make room for the siphons. There is no external difference between the male and female, and the eggs are fertilized in the water after being ejected by the female.

Spawning.—*Pholas* spawns in July, for some of them about the end of June were not ripe. As the tides were unsuitable, it was not until July 27th that a further examination showed ripe eggs and ripe sperms, and some eggs were fertilized by taking a few ripe specimens of *Pholas*, cutting them in pieces, putting them in water, and letting them stand for a short time. The separate fragments were then placed under running water until it was clear, when the eggs were transferred to clean water for examination. As the development of this type of mollusc is well known, it is unnecessary to describe it. The egg is surrounded by a thick dark brown membrane, within which there is a thin clear white layer, internal to which is the yellowish granular protoplasm. Within the protoplasm is a large nucleus, and within the nucleus a small body (nucleolus). The larvæ, unlike the parent, are free swimming. How they become attached to the rock and commence boring has not been observed. The smallest example found was an eighth of an inch long, and had already penetrated half an inch into the shale.

Boring.—Each *Pholas* lives in its hole; they may be very close together, and the divisions between them may be as thin as paper. Only once have I found two in one hole or burrow. The hole is narrowest at the top, is egg-shaped at the bottom, the greatest width being a short distance above the base. How the creature bores is not exactly known, though various views are current. The different methods suggested may be grouped as mechanical, chemical, and electrical. Mechanical means seems to me the most likely, but whether the shell only is used, or the foot alone, or both together, is not easy to determine. The fact that the widest part of the hole is

equal in diameter to the greatest width of the shell, while the foot alone projects farther into the cavity, would seem to show that the foot only is used. In the first instance, I think that the foot used in conjunction with the siphons acts as a pump, the fragments of sandstone, shale, and mud loosened by the foot being ejected by the siphons and got rid of. Exactly the same process is adopted on ships and boats where the pumps are close to the keel. I have seen a cup-shaped hole worn in the solid oak purely by suction. The objection may be raised that this is due to oxide of iron, but in my experience (that is, forty years ago) wooden pumps were most commonly used. Many a ship has been lost through the pump sinking into the cavity so formed, and becoming choked and useless. However accomplished, the power of boring possessed by *Pholas* is very considerable, for I have seen a burrow bored through three inches of hard ferruginous sandstone, and six inches into the shale beneath.

Economic Uses.—*Pholas* was used by the fishermen at St. Andrews sixty years ago as bait for Cod and Haddock. At that time much of the shale where the mollusc lived was dug up; not an example of *Pholas* is now to be seen at those parts, although these shellfishes are abundant where the shale has not been disturbed. Like all other living creatures, they have to bear their part in the struggle for existence; by far the greater part of the larvæ must perish through failing to find a proper resting place, or by being devoured. Even the adults in their burrows are not secure, for crustaceans (sessile-eyed) devour them, and sponges and polyzoa grow over the mouths of their burrows, preventing the ingress of food and water for respiration; by this latter occurrence many of the adult forms are killed.

Other boring Molluscs.—*Pholas* is not the only mollusc which makes a burrow. *Tapes*, *Saxicava*, *Mya*, *Solen*, and the common Limpet all construct tunnels. *Solen* burrows in the sand, and if dug out of the burrow and laid on the surface of the sand they protrude the foot and penetrate into the sand like a plough until deep enough to suit them. The foot then swells and shortens, drawing the shell down after it. The foot is again extended downwards, a new grip is taken, and the process is repeated until the creature is finally pulled downwards out of sight. Such is the *Solen's* method of escape. *Mya* bores through clay in exactly the same manner.

The smallest *Pholas* I ever found in the shale was about the size of a hemp-seed, and penetrated about one inch. The hole on the outside was only a hair's-breadth in diameter. The *Pholas* itself was in a small cavity. As it continues boring it makes the hole larger until it gets down about six or eight inches. When the *Pholas*

is to a depth in the shale of about three inches it measures externally round the shell about one inch and a half, but at a depth of eight inches it measures three and two-eighths of an inch round the shell at the widest part. The hole of the young one from the outside was not visible, but the hole of the second example was about half an inch, and the large one was a little wider. The method by which *Pholas* makes its hole in the rock or shale is as follows:—As soon as the *Pholas* gets underneath the deposit that is lying on the rock it begins to bore with its foot until it gets a cavity, then it moves its foot round and round, sucking away all the time, and pumping out the sand or shale with its siphons. As it grows larger it finds its hole too small for its siphons; it then uses its siphons to make its hole larger, when the *Pholas* is able to bore with its fleshy siphons upwards, so that it can bore with its fleshy foot downwards. To sum up, I conclude that *Pholas* working outwards with its siphons increases the size of the hole, which was at first merely a scratch in the rock. The downward boring must be accomplished by the foot only.—A. W. Brown (Gatty Marine Laboratory, St. Andrews, N.B.).

VERMES.

The Angler as a Factor in the Distribution of Earthworms.—It is well known that the presence of some fishes in our inland waters may be traced to the angler, who, after a day's live-bait fishing, empties the remaining contents of his bait-can, procured from other sources, into the water he has fished. On reading Mr. Friend's valuable notes on the distribution of British earthworms, I was impressed with the probability of a similar agency at work, in, however, more circumscribed limits. The angler, when worm-fishing, has usually purchased his worms from a tackle-shop, and these annelids are procured by the dealer from many and wide sources. They are usually vended as the lob-, marsh-, red-, and brandling-worms, while "cockspurs" are sent from Leeds, and "pink-tails" from Edinburgh. Among the first-named—lob-, marsh-, and red-worms—I have frequently noticed strangers, but all are consigned to the worm-bag, the selection being made while angling, and the remainder being usually thrown away at the end of the day. It is in this pocess of "throwing away" that any interest in this note occurs. Some anglers empty the worm-bag in the water, and there is an end of the matter. As regards myself—and doubtless I am not alone—I always feel that the least I can do for the remainder of my annelid friends who have helped to provide the sport of the day is to empty the worm-bag in some damp spot in the meadow where for the time being I may be. In a moderately long experience as an angler I must have thus distributed earthworms from one county to another, and from north to south. Others must have probably done the same. Mr. Friend, with his great knowledge of these creatures, might find some little expected species on the banks and adjoining meadows of streams and lakes that anglers frequent.—W. L. Distant.